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| TITLE: | EXPOSURE METHOD, MASK FABRICATION METHOD, FABRICATION METHOD OF SEMICONDUCTOR DEVICE, AND EXPOSURE APPARATUS |

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SIR;

CERTIFIED TRANSLATION

I, Kaoru TASAKA, am an official translator of the Japanese language into the English language and I hereby certify that the attached comprises an accurate translation into English of Japanese Application No. 2002-189086, filed on June 28, 2002.

I hereby declare that all statements made herein of my own knowledge are true and that all statement made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

June 8, 2006
Date

Kaoru TASAKA

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[Name of the Document] SPECIFICATION

[Title of the Invention] EXPOSURE METHOD, MASK FABRICATION METHOD, AND FABRICATION METHOD OF SEMICONDUCTOR DEVICE

[WHAT IS CLAIMED IS:]

[Claim 1]

An exposure method for transferring a desired pattern on an exposure target utilizing a reflective mask for an extreme ultra violet ray, characterized by comprising the steps of:

providing respective reflective mask each having a mask pattern consisting of only pattern forming elements of the same direction by dividing pattern forming elements of the mask pattern corresponding to said desired pattern relative to a projection vector of said extreme ultra violet ray;

sequentially carrying out a pattern transfer on said exposure target by irradiating said extreme ultra violet ray and a reflection light thereof with regard to respective reflective mask in the respective direction; and

rotating, at the time when one reflective mask is changed to the other reflective mask, said other reflective mask and said exposure target so that an angle of the pattern forming elements of said other reflective mask and the projection vector becomes equal to an angle of the pattern forming elements of said one reflective mask and the projection vector.

[Claim 2]

The exposure method as claimed in Claim 1, characterized in that:

said reflective mask of the respective direction includes a V-line mask in which a pattern only including the pattern forming elements perpendicular to said projection vector is formed, and an H-line mask in which a pattern only including the pattern forming elements horizontal to said projection vector is formed.

[Claim 3]

A mask fabrication method for transferring a desired pattern on an exposure target utilizing a reflective mask for an extreme ultra violet ray, characterized by comprising the steps of:

dividing pattern forming elements of a mask pattern corresponding to said desired pattern with regard to respective direction relative to a projection vector of said extreme ultra violet ray;

forming respective reflective mask each having a mask pattern consisting only of pattern forming elements of the same direction with regard to the respective direction; and

configuring respective reflective mask of respective direction so that when the reflective mask and said exposure target are rotated relative to said projection vector, an angle of the pattern forming elements of respective reflective mask and the projection vector is always the same.

[Claim 4]

The mask fabrication method as claimed in Claim 3, characterized in that:

said reflective mask of the respective direction includes a V-line mask in which a mask pattern only including the pattern forming elements perpendicular to

said projection vector is formed, and an H-line mask in which a mask pattern only including the pattern forming elements horizontal to said projection vector is formed.

[Claim 5]

A fabrication method of a semiconductor device including a lithography process for transferring a desired pattern on an exposure target using a reflective mask for an extreme ultra violet ray, characterized by comprising the steps of:

providing respective reflective mask each having a mask pattern consisting only of pattern forming elements of the same direction with regard to the respective direction by dividing pattern forming elements of the mask pattern corresponding to said desired pattern relative to a projection vector of the extreme ultra violet ray;

sequentially carrying out transfer of said mask pattern on said exposure target by irradiating said extreme ultra violet ray and its reflection light with regard to respective reflective mask in the respective direction; and

rotating, at the time when one reflective mask is changed to the other reflective mask, said other reflective mask and said exposure target so that an angle of the pattern forming elements of said other reflective mask and the projection vector becomes equal to an angle of the pattern forming elements of said one reflective mask and the projection vector.

[Claim 6]

The fabrication method of a semiconductor device as claimed in Claim 5, characterized in that:

said reflective mask of the respective direction includes a V-line mask in which a mask pattern only including the pattern forming elements perpendicular to said projection vector is formed, and an H-line mask in which a mask pattern only including the pattern forming elements horizontal to said projection vector is formed.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to an exposure method used in a lithography process for forming a circuit pattern of a semiconductor device, a mask fabrication method of an exposure mask used in this lithography process, a fabrication method of a semiconductor device including the lithography process, and in particular, to an exposure method using a reflective mask adaptable to a so-called extreme ultra violet ray, a fabrication method of the mask and a fabrication method of a semiconductor device.

[0002]

[Prior Art]

In a lithography process that is one of processes for fabricating a semiconductor device, a wave-length of a light source in an exposure apparatus tends to be shorter along with the miniaturization of forming pattern. For example, the light source has been changed from an i-ray (wave-length = 365 nm) to a KrF Excimer (wave-length = 248 nm), to an ArF Excimer (1 wave-length = 93 nm), and to an F2 (1 wave-length = 53 nm). This means that in order to principally improve the resolution, it is performed by the increase of a numerical aperture (NA) of

a projection optical system and the shortened wave-length of the exposure light. Generally, it is well-known that the resolution determined by the wave-length of an exposure light is expressed by the Rayleigh's formula as $w = K1 \times (\lambda / NA)$, wherein w is a resolution of a pattern, NA is a numerical aperture of the projection optical system, and $\lambda$ is a wave-length of the exposure light. Further, K1 is a positive constant of 1 or less determined by the resist and the process used in the exposure process.

[0003]

Further, it has recently been proposed to use a so-called Extreme Ultra Violet ray (EUV) such as a light of a soft X-ray region having a wave-length of 5 to 15 nm as the exposure light in order to cope with further miniaturization of a pattern. In a case where the EUV ray is employed, the resolution w = 43 nm is obtained from the above-mentioned Rayleigh's formula, provided that the K1 = 0.8, the NA= 0.25, and the wave-length of the EUV ray as the exposure light is 13.5 nm. Then, it becomes possible to carry out the process of the pattern that is compliant with a design rule for 50 nm pattern width. To that end, the EUV exposure technology is expected to be a future exposure technology as a possible candidate.

[0004]

However, regarding the EUV ray, there is not any material (substance) that does not absorb but does transmit the EUV ray, so that it is impossible, for the EUV ray, to configure a light transmission type projection optical system that is widely applied in a

conventional lithography process. Accordingly, it is necessary to configure a reflection type projection optical system (including a reflective mask and a reflection type optical system for reflecting a light) in a case of using the EUV ray.

[0005]

Fig. 3 is a schematic diagram showing one example of an exposure apparatus constituting a reflection type projection optical system. The exposure apparatus in Fig. 3 includes a light source 1 for the EUV ray, a reflective mask 2 and a reflection type optical system 3 (plural reflection mirrors, for example), a mask holder 4 for holding the reflective mask 2, a movable reticle stage 5, a wafer holder 6, and a movable wafer stage 7. A wafer 8 as an exposure target is to be held on the movable wafer stage 7 by way of the wafer holder 6. As the light source 1 for the EUV ray, a laser plasma system may be exemplified, in which a high power laser light such as the Excimer laser and the like is focused and irradiated on the EUV ray radiating material such as rare gas spouting from a not-shown nozzle, and generates the EUV ray upon transiting to a low potential condition so that the material is excited to be in plasma state. And the EUV ray irradiated from the light source 1 passes through the reflective mask 2 and the reflection type optical system 3, thereby the pattern (the mask pattern) formed on the reflection plane of the reflective mask 2 is transferred on the wafer 8 as an LSI pattern (circuit pattern that is necessary for configuration of the semiconductor device). In this case, an illuminated area on the reflective mask 2 is formed in a ring shape, and

further, a scanning exposure system is employed, in which the pattern on the reflective mask 2 is sequentially transferred on the wafer 8 by scanning the reflective mask 2 and the wafer 8 relatively to the reflection type optical system 3.

[0006]

Fig. 4 is a perspective view showing a structural example of the reflective mask 2 used in the exposure apparatus. As shown in this figure, it is known such mask that is equipped with a mask blank 2a for reflecting the EUV ray and an EUV ray absorption film 2b formed so as to cover the reflection plane of the mask blank 2a. The mask blank 2a has a multi-layered film structure formed by alternately stacking a Mo (Molybdenum) film and a Si (Silicon) film, and the repetition number of the stacks is usually 40. By the multi-layered film structure as described above, the mask blank 2a reflects the EUV ray having 13.5 nm in wave-length at reflectivity of approximately 70%. Further, by covering the reflection plane of the mask blank 2a with the absorption film 2b having corresponding pattern thereof, the reflection of the EUV ray is selectively carried out. It is noted that, if the reflection material such as multi-layered film is carried out the patterning to the absorption film blank, the recovery upon failure is impossible, but if the patterning is carried out by providing such absorption film 2b, it becomes possible to try again and becomes easy to repair the pattern, so that it is preferable to cover the mask blank 2a with the absorption film 2b.

[0007]

In a case of using such reflective mask 2, the light reflected at the reflection plane has to be introduced to the reflection type optical system 3 without mutually interfering with the incident light to the reflection plane. Accordingly, the incident light to the reflective mask 2 has to be a skewed incident light having an incident angle θ relative to a normal line of the reflection plane. The incident angle θ of the incident light is determined by the NA of illumination (hereinafter referred to as an NAill) at the reflection plane, and this is determined by the NA at a wafer surface of a reflective type projection optical system and a magnification of projection based on a desired resolution. For example, provided that the magnification of projection is 4 times system taking over the magnification of projection of a conventional exposure apparatus, the incident angle θ of the incident light to the reflective mask 2 becomes around 4 degrees when the level of the NA = 0.2 to 0.3 determined by the desired resolution.

[0008]

[Problem to be solved by the Invention]

However, in a case of the skewed incidence as described above, the pattern width transferred on the wafer 8 fluctuates depending on the direction of the mask pattern on the reflective mask 2 relative to the projection vector of the incident light.

[0009]

In this case, if the mask pattern is for transferring the LSI pattern, for example, the direction of the mask pattern is divided by whether the mask

pattern is parallel or perpendicular relative to the direction of the projection vector of the EUV ray. In other words, the mask pattern for transferring the LSI pattern is normally able to be divided into pattern forming elements having sides parallel to the direction of the projection vector and pattern forming elements having sides orthogonal to the direction of the projection vector. Accordingly, each pattern forming elements constituting the mask pattern is defined as described herein after in the text.

[0010]

Fig. 5 is a conceptual diagram for explaining the direction of the mask pattern. As shown in the figure, the mask pattern formed on the reflective mask 2 is scanned in the Y direction in the figure as the movable reticle stage 5 moves (see Fig. 3), and thereby, the mask pattern is transferred on the wafer 8. The incident angle θ (4 degrees, for example) of the EUV ray incoming askew at this time is the angle around the X axis in the figure. Accordingly, the pattern forming elements extending in the direction parallel to the scanning direction of the mask pattern, namely the pattern forming elements having sides parallel to the direction of the projection vector are defined as a V-line (Vertical-line). On the contrary, the pattern forming elements extending in the direction perpendicular to the scanning direction of the mask pattern, namely the pattern forming elements having sides orthogonal the direction of the projection vector are defined as an H-line (Horizontal-line).

[0011]

Fig. 6 is an explanatory view for showing one

specific example obtained by simulating the difference of the pattern width of the V-line and the H-line after pattern transfer in the case of the EUV ray incident askew. Generally, in a case of strictly simulating the difference of the pattern width of the V-line and the H-line, it is necessary to introduce a three-dimensional electromagnetic field simulation in consideration of the thickness of the absorption film 2b (Fig. 4) on the reflective mask 2, but in the figure, it is approached by the case where the EUV ray incident on a two dimensional binary mask, provided that the thickness of the absorption film 2b is zero. In the result of the simulation depicted in Fig. 6, the transferred line width of a line and a space of every V-line and H-line on the wafer 8 is calculated under the condition where the wave-length of the EUV ray = 13.5 nm, the NA = 0.25, the $\sigma$ = 0.70, the incident angle on the mask = 4 degrees (around X axis), the magnification of projection is 4, and the pattern width of the line and the space on the wafer = 50 nm. According to the simulation result, it is recognized that there is the line width difference of around 4 nm between the V-line and the H-line in the range of the focus range of ± 0.1 μm. Further, it is recognized that the fluctuation of the V-line and the H-line within the focus range is around twice thereof.

[0012]

As described above, in the case of the EUV ray incident askew on the reflective mask 2, the width of the line pattern transferred on the wafer 8 is fluctuated depending on the direction of the mask pattern relative to the projection vector, and as a result, it is probable

to cause an adverse effect to the resolution of the transferred image. However, various technologies have been conventionally proposed regarding the correction for removing the width difference between the V-line and the H-line, but the technology for improving the margin difference of the resolution depending on the incident angle of the EUV ray upon exposure process which causes fluctuation in the width difference between the V-line and the H-line is not particularly proposed. Further, the width of the transferred pattern also depends on the repetition rate (pitch) or the crude density of the pattern on the reflective mask 2 (herein after, this is called as an OPE (Optical Proximity Effect) characteristic), and this OPE characteristic also fluctuates depending on the incident angle of the EUV ray.

[0013]

According to the present invention, it is so arranged not to cause the difference of the pattern width between the V-line and the H-line, namely the influence caused by the direction of the mask pattern relative to the projection vector in principle, without depending on the correction of the mask pattern, for example. Namely the present invention is to propose an exposure method capable of improving margin difference of the resolution in the transferred image without introducing misalignment or deformation (distortion in pattern width) of the transferred image, a mask fabrication method, and a fabrication method of a semiconductor device.

[0014]

[Means for solving the problem]

The present invention is made to attain the above-

mentioned object. Namely, the present invention is an exposure method for transferring a desired pattern on an exposure target using a reflective mask for an extreme ultra violet ray, which is characterized in that pattern forming elements of a mask pattern corresponding to the above-mentioned desired pattern are divided with regard to respective direction relative to the projection vector of the extreme ultra violet ray and a set of reflective mask patterns each having only the pattern forming elements of the same direction is provided, the transfer of the pattern on the exposure target is sequentially carried out by the irradiation and the reflection of the extreme ultra violet ray with regard to the reflective mask of respective direction, and, at the time when the one reflective mask is changed to the other reflective mask, the other reflective mask and the exposure target are rotated relative to the projection vector so that the angle of the pattern forming elements of the other reflective mask and the projection vector is becomes equal to the angle of the pattern forming elements of the one reflective mask and the projection vector.

[0015]

Further the present invention is a mask fabrication method that is made to attain the above-mentioned object. Namely, the present invention is a fabrication method for fabricating a reflective mask to be used for transferring a desired pattern on an exposure target by reflecting an extreme ultra violet ray, which is characterized in that pattern forming elements of a mask pattern corresponding to the above-mentioned desired pattern are divided with regard to respective direction relative to the projection

vector of the extreme ultra violet ray, and a set of reflective mask patterns each having only the pattern forming elements of the same direction is provided. With regard to respective reflective mask, each reflective mask and the above-mentioned exposure target are rotated relative to the projection vector so that the angle of each of reflective mask and the projection vector is always the same.

[0016]

Further the present invention is a fabrication method of a semiconductor device that is made to attain the above-mentioned object. Namely, the present invention is a fabrication method of a semiconductor device including a lithography process for transferring a desired pattern on an exposure target by using a reflective mask for an extreme ultra violet ray, which is characterized in that pattern forming elements of a mask pattern corresponding to the above-mentioned desired pattern are divided with regard to respective direction relative to the projection vector of the extreme ultra violet ray and a set of reflective mask patterns each having only the pattern forming elements of the same direction is provided, the projection of the pattern on the exposure target is sequentially carried out by the irradiation and the reflection of the extreme ultra violet ray with regard to the reflective mask of respective direction, and, at the time when the one reflective mask is changed to the other reflective mask, the other reflective mask and the exposure target are rotated relative to the projection vector so that the angle of the pattern forming elements of the other

reflective mask and the projection vector is becomes equal to the angle of the pattern forming elements of the one reflective mask and the projection vector.

[0017]

According to the exposure method, the mask fabrication method, and the fabrication method of a semiconductor device according to the above-mentioned procedures, the mask patterns corresponding to a desired pattern to be formed on an exposure target are divided into V-line pattern forming elements and H-line pattern forming elements with regard to respective direction, and a pair of reflective mask patterns each corresponding to respective direction is provided. Then, when the one reflective mask is changed to the other reflective mask, the other reflective mask and the exposure target are rotated. Thereby, the angle of the pattern forming elements of the respective mask and the projection vector becomes always the same. Accordingly, even in the case of the extreme ultra violet ray incident askew on the reflective mask, there is no possibility of causing the difference in the width of the transferred pattern depending on the angle between the pattern forming elements and the projection vector.

[0018]

[Practical form for Implementing the Invention]

Hereinafter, an exposure method, a mask fabrication method, a fabrication method of a semiconductor device, and an exposure apparatus according to the present invention will be described with reference to the drawings. However, only the difference from a conventional one is explained, and explanations for the

configuration of an exposure apparatus which is similar to the conventional one (see Fig. 3), and the configuration of a reflective mask itself (see Fig. 4) are omitted here.

[0019]

Fig. 1 is an explanatory view showing a brief overview of an exposure method according to the present invention. In a lithography process that is one of processes for fabricating a semiconductor device, the exposure method explained here is applied to the transfer of an LSI pattern necessary for configuring the semiconductor device on a wafer as an exposure target. In more detail, this exposure method is applied, while using a reflective mask for an EUV ray (wave-length = 13.5 nm, for example) to transfer a mask pattern formed on the refection type mask on the wafer, thereby forming the LSI pattern on the wafer.

[0020]

The mask pattern at this time includes pattern forming elements 11a of a V-line extending in a parallel direction relative to a direction of a projection vector of a skewed incident EUV ray as shown in Fig. 1(a), and pattern forming elements 11b of an H-line extending in a vertical direction relative to the projection vector. In order to transfer such mask pattern on a wafer, a reflective mask is prepared (formed) by the procedures as described below.

[0021]

Fig. 2 is a flowchart showing a flow of procedures of a mask fabrication method according to the present invention. As shown in the figure, when forming the

pattern of the reflective mask in the present embodiment, input design data (data for whole pattern) are acquired for the mask pattern corresponding to the LSI pattern to be formed on a wafer (Step 101, hereinafter, step is abbreviated to "S"). As the input design data, CAD (Computer Aided Design) data may correspond to them, for example. Then, the input design data are divided into V-line data corresponding to the pattern forming elements 11a of the V-line, and H-line data corresponding to the pattern forming elements 11b of the H-line.

[0022]

To be more specific, with regard to the input design data, a desired size in X-direction is erased in accordance with over-size and under-size of only for an X direction (S102), the graphic data only for the X direction are extracted (S103). In this case, a coordinate space on the input design data is consistent with a coordinate space upon exposure. Accordingly, the graphic data extending in the X direction correspond to the H-line data, and the graphic data extending in the Y direction (that is, the operating direction of the exposure apparatus) correspond to the V-line data. After the graphic data only for the X direction are extracted, then the graphic data only for the X direction are subtracted from the input design data (S104), and the rest of the graphic data are extracted therefrom (S105). These rest of the graphic data are to correspond to the graphic data extending in the Y direction, namely, the V-line data. As described above, in a case of forming such reflective mask, it is necessary to divide the input design data for the mask pattern into the V-line data and

the H-line data relative to respective direction with regard to the direction of the projection vector of the EUV ray.

[0023]

Then, on the basis of the divided V-line data and H-line data, as shown in Fig. 1(b), a V-line mask 12a having a mask pattern consisting only of the pattern forming elements 11a for the V-line and an H-line mask 12b having a mask pattern consisting only of the pattern forming elements 11b for the H-line are respectively formed. Thus, the reflective masks 12a and 12b for respective direction are prepared.

[0024]

In this case, the V-line mask 12a and the H-line mask 12b may be formed with a conventional method, so that the explanation thereof is omitted here. Further, regarding the division of the input design data into the divided V-line data and H-line data, it is not always necessary to carry out by the above-mentioned procedures, and other graphic processing technology already known may be applied.

[0025]

After the V-line mask 12a and the H-line mask 12b are prepared, the mask pattern is at first transferred on the wafer 8 using one of the two masks. Namely, the EUV ray is irradiated on one of the V-line mask 12a and the H-line mask 12b, and forms on the wafer 8 either the mask pattern consisting only of the pattern forming elements 11a for the V-line or an H-line mask 12b having the mask pattern consisting only of the pattern forming elements 11b for the H-line by allowing the reflection light to

arrive on the wafer 8.

[0026]

After one of the pattern image is transferred, the mask pattern of the other reflective mask 12a, or 12b is transferred on the wafer 8. For example, in a case where the process for the exposure and transfer by using the V-line mask 12a has been completed, then the process for the exposure and transfer by using the H-line mask 12b is carried out. In this case, the relative position of the H-line mask 12b which corresponds to the other reflective mask is rotated approximately by 90 degrees relative to the projection vector of the EUV ray. Further as shown in in Fig. 1(c), the relative position of the wafer 8 on which the pattern is to be transferred is also rotated approximately by 90 degrees relative to the projection vector of the EUV ray.

[0027]

Thereby, even if the irradiation target of the EUV ray is changed to the other reflective mask, namely to the H-line mask 12b, an angle of the pattern forming elements 11b of the H-line mask 12b and the projection vector of the EUV ray becomes equal to an angle of the pattern forming elements 11a of the V-line mask 12b, which is either one of the reflective mask to which the exposure and transfer process has been completed, and the projection vector of the EUV ray. Further, because the wafer 8 is also rotated by approximately 90 degrees, the transferred pattern image as desired is to be correctly formed on the wafer 8, even if the H-line mask 12b is rotated by approximately 90 degrees when the mask is changed to the H-line mask 12b.

[0028]

As explained above, according to the present embodiment, the V-line mask 12a and the H-line mask 12b are provided or formed by dividing a mask pattern into two regarding respective direction relative to the projection vector of the EUV ray. Then, the exposure and transfer processes by using respective reflective mask 12a and 12b are sequentially carried out. In this case, exposures are to be carried out twice by rotating the other mask and the wafer 8 at the time when the reflective masks 12a and 12b are changed from the one to the other. Therefore, even in the case where the EUV ray is coming askew to respective reflective mask 12a and 12b, the angle of the projection vector of the EUV ray and the respective pattern forming elements 11a and 11b of the respective reflective mask 12a and 12b is always the same. Accordingly, no adverse effect due to the angle of the projection vector and the pattern forming elements 11a and 11b principally occurs even without depending on the correction of the mask pattern, so that it is as much possible to avoid occurrence of misalignment or deformation (distortion of pattern width) of the transferred image. As a result, it is able to prevent the adverse effect of the direction of the mask pattern to the resolution of the projected image.

[0029]

Particularly, if, as explained in the above mentioned embodiment, the exposure process is carried out twice using the V-line mask 12a and the H-line mask 12b in this order, and the extending directions of the pattern forming elements 11a and 11b are aligned in the

direction of the projection vector of the EUV ray, it becomes very effective in improving the resolution of the projected image on the wafer 8 even when the EUV ray is incoming askew.

[0030]

It is noted that, in a case of forming an LSI pattern on the wafer 8, the pattern is composed of forming elements mainly extending in the directions of the V-line and the H-line, so that, as explained in the above mentioned embodiment, it is effective to expose twice using the V-line mask 11a and the H-line mask 11b from the perspective of the resolution, the efficiency of the process and the like. However, the present invention is not limited to expose twice using the V-line mask 11a and the H-line mask 11b. For example, if sequential exposures and relative positional rotations are carried out with regard to respective direction by providing respective reflective mask with regard to respective direction regarding the projection vector of the EUV ray, the exposure process may be carried out three times or more. That is, the above mentioned is one of embodiments of the present invention, and the scope of the present invention is not limited to this.

[0031]

[Effect of the Invention]

As described above, according to the present invention, influence due to the direction of the mask pattern with regard to the projection vector can be prevented from occurring in principle depending on the exposure process divided into more than once, not depending on the mask pattern correction, for example.

Accordingly, even in the case of the extreme ultra violet ray incoming askew with regard to each reflective mask, the margin difference of the resolution of the transferred image can be improved more than a conventional case without introducing misalignment or deformation (distortion of pattern width) of the transferred image.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is an explanatory view showing a brief overview of an exposure method according to the present invention, in which (a), (b), and (c) show procedures of the exposure method.

[Fig. 2]

Fig. 2 is a flowchart showing a flow of procedures of a mask fabrication method according to the present invention.

[Fig. 3]

Fig. 3 is an explanatory view showing an example of an exposure apparatus constituting a reflection type projection optical system.

[Fig. 4]

Fig. 4 is a perspective view showing one structural example of a reflective mask used in the exposure apparatus in Fig. 3.

[Fig. 5]

Fig. 5 is a conceptual diagram for explaining a direction of a mask.

[Fig. 6]

Fig. 6 is an explanatory view for showing one specific example obtained by simulating difference of a

pattern width of a V-line and an H-line after transfer in a case of an extreme ultra violet ray incident askew.

[Description of Reference Numerals]

8...wafer, 11a...pattern forming element of V-line, 11b...pattern forming element of H-line, 12a...V-line mask, 12b...H-line mask

[Name of the Document]

[Drawings]

[Fig. 1]

(a)

11b H-LINE PATTERN FORMING ELEMENT

11a V-line pattern forming element

(b)

12b H-LINE MASK

12a V-LINE MASK

(c)

8 wafer

[Fig. 2]

S101 INPUT DESIGN DATA

S102 SUBTRACT FROM INPUT DATA BY ERASING DESIRED SIZE DATA IN THE X DIRECTION WITH UNDER-SIZE AND OVER-SIZE ONLY IN THE X DIRECTION

S103 GRAPHIC DATA ONLY IN THE X DIRECTION

S104 SUBTRACT GRAPHIC DATA ONLY IN THE X DIRECTION FROM INPUT GRAPHIC DATA

S105 REST OF GRAPHIC DATA

[Fig. 3]

[Fig. 4]

ＥＵＶ光 EUV RAY

入射角Θ INCIDENT ANGLE θ

[Fig. 5]

走査方向 SCANNING DIRECTION

ＥＵＶ光 EUV RAY

[Fig. 6]

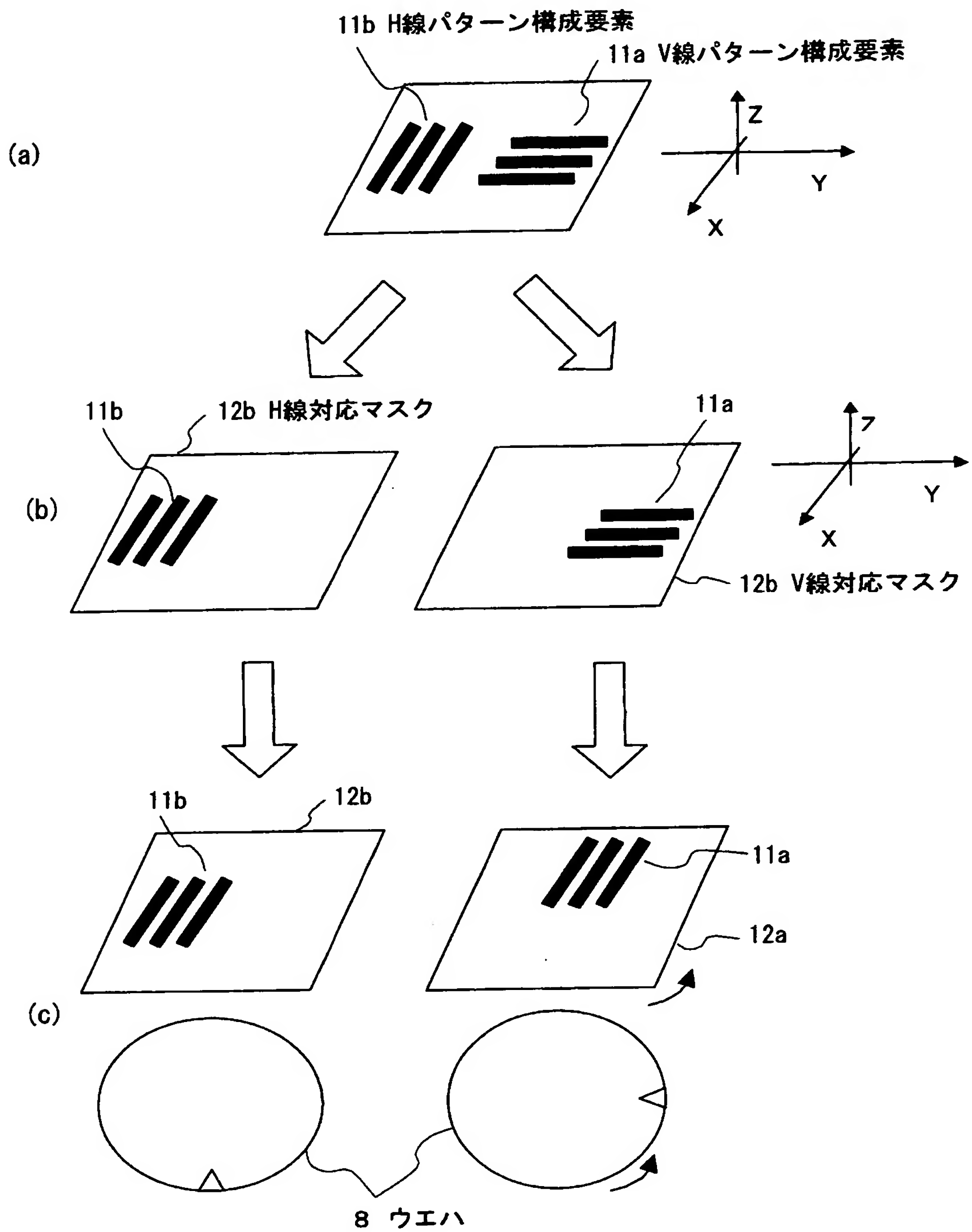
ＶＨ線のＣＤフォーカスカーブ

CD FOCUS CURVE FOR V-LINE AND H-LINE

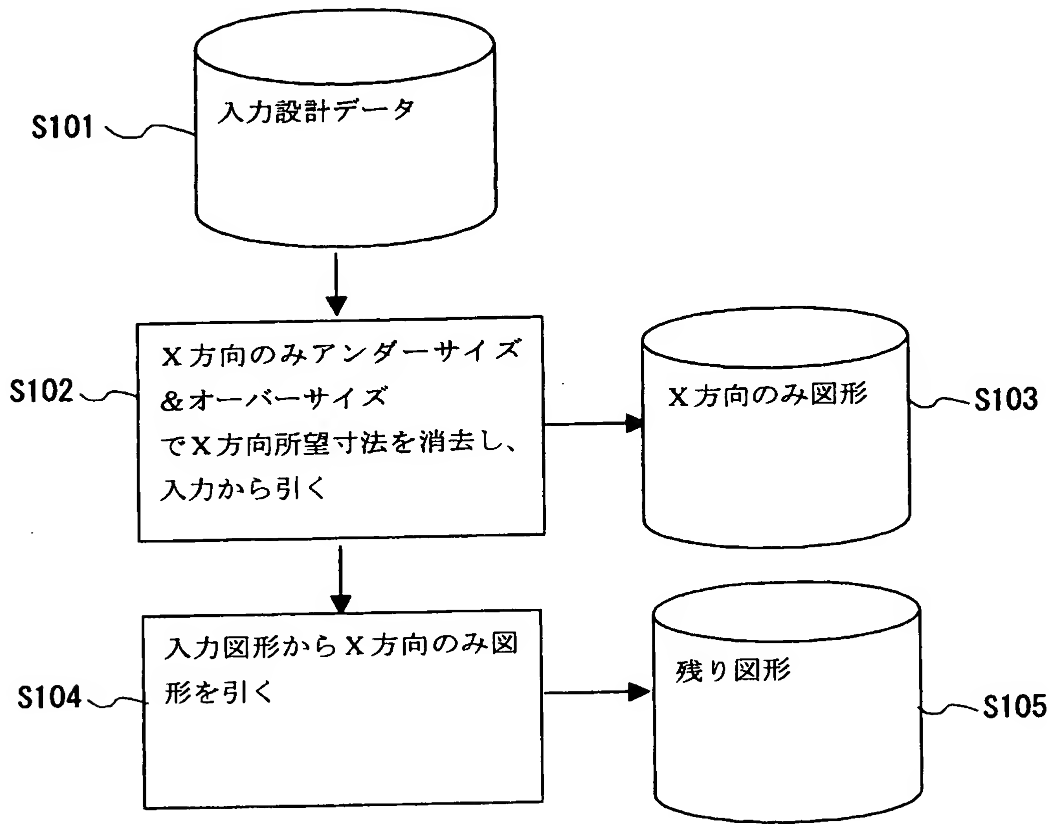
入射角度 INCIDENT ANGLE

【書類名】　図面

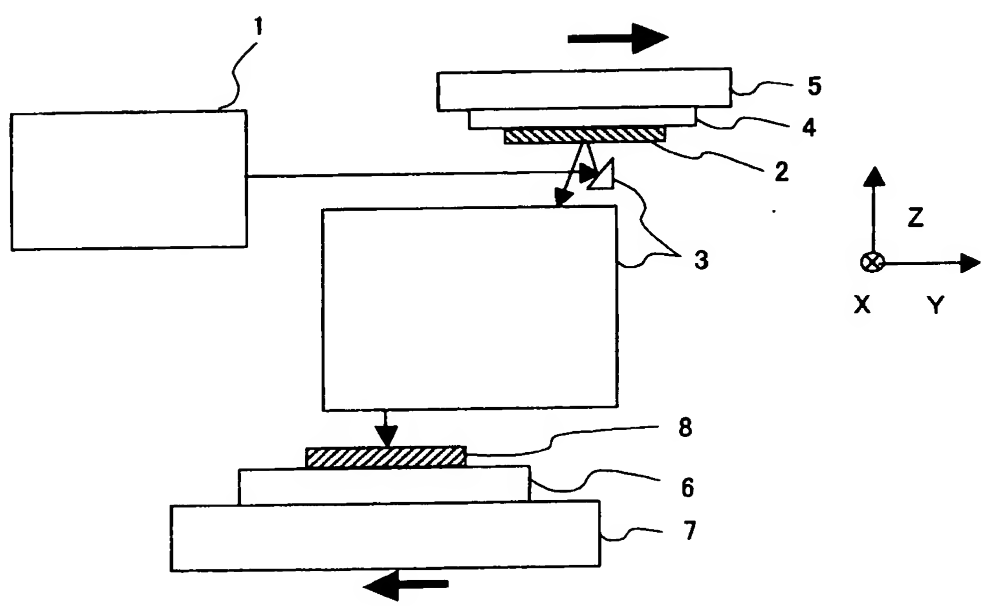
【図１】


11b H線パターン構成要素
11a V線パターン構成要素
(a)
Z
Y
X
(b)
11b
12b H線対応マスク
11a
Z
Y
X
12b V線対応マスク
(c)
11b
12b
11a
12a
8 ウエハ

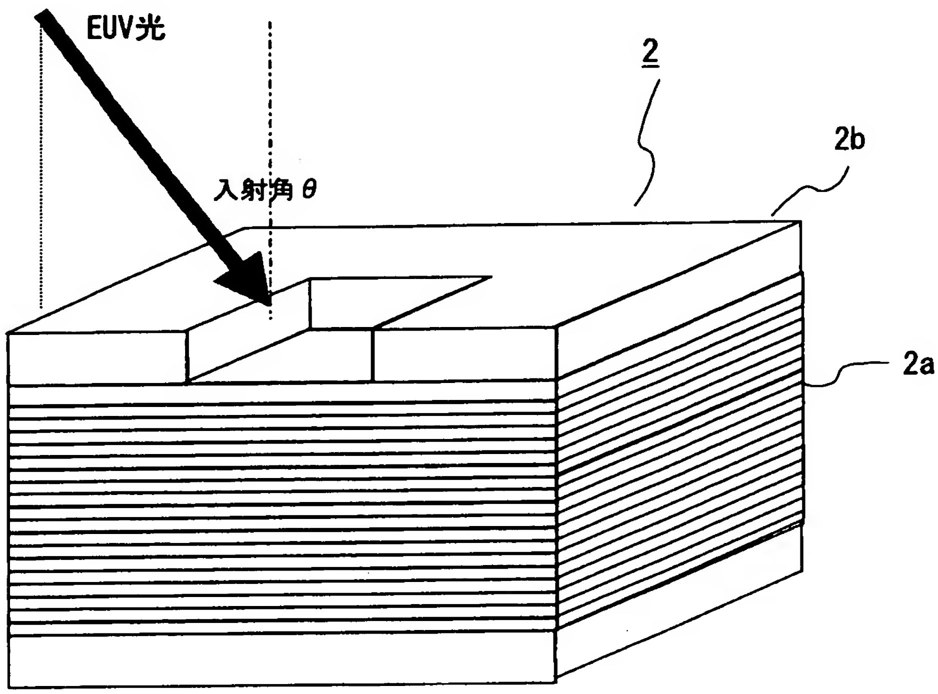
【図２】


S101
入力設計データ
S102
X方向のみアンダーサイズ
&オーバーサイズ
でX方向所望寸法を消去し、
入力から引く
X方向のみ図形
S103
S104
入力図形からX方向のみ図
形を引く
残り図形
S105

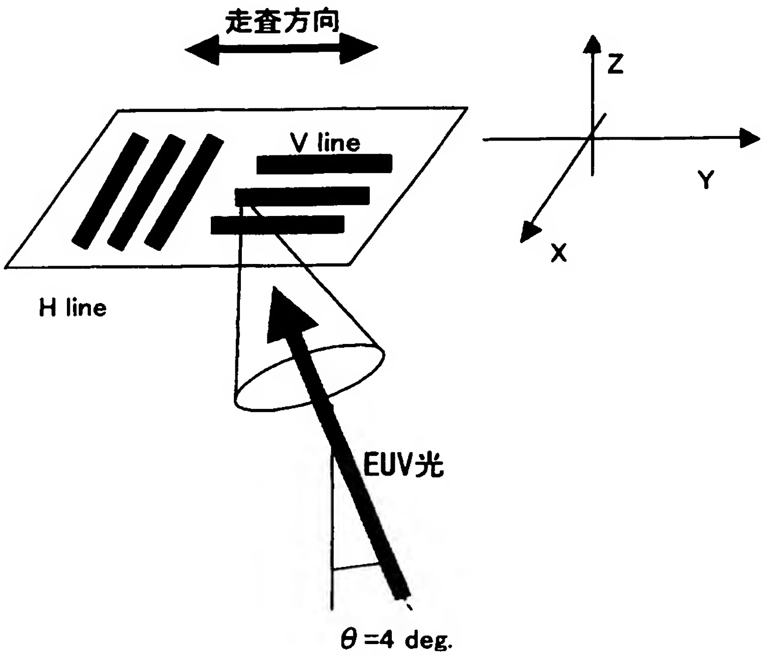
【図３】


1
5
4
2
3
Z
X
Y
8
6
7

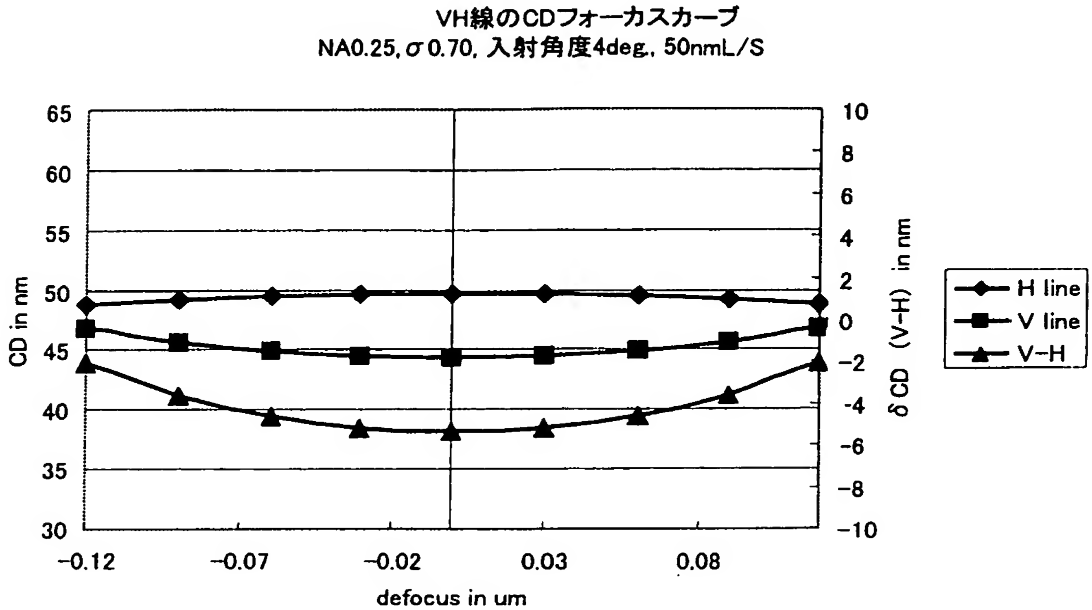
【図４】



【図５】



【図６】


VH線のCDフォーカスカーブ
NA0.25, σ0.70, 入射角度4deg., 50nmL/S
65
60
55
50
45
40
35
30
CD in nm
10
8
6
4
2
0
-2
-4
-6
-8
-10
δCD (V-H) in nm
-0.12
-0.07
-0.02
0.03
0.08
defocus in um
H line
V line
V-H

[Name of the Document]

ABSTRACT OF THE DISCLOSURE

[Abstract]

[Object]

In a lithography process, even in a case of an extreme ultra violet ray incident askew with regard to a reflective mask, occurrence of misalignment or deformation (distortion in pattern width) of a transferred image due to the direction of a mask pattern is avoided.

[Solution means]

Pattern forming elements 11a, 11b of a mask pattern are divided relative to directions of a projection vector of an extreme ultra violet ray, pattern transfer on an exposure target 8 is sequentially carried out using reflective masks 12a, 12b of respective direction composed only of pattern forming element group of the same direction, and, at the time when one reflective mask is changed to the other reflective mask, the other reflective mask and the exposure target are rotated so that an angle of the pattern forming elements of the other reflective mask and the projection vector becomes equal to an angle of the pattern forming elements of the one reflective mask and the projection vector.

[Selected Drawing]

Fig. 1